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ECONOMIC COMMISSION FOR AFRICA

ESTABLISHMENT OF THE AFRICAN NUCLEAR ENERGY COMMISSION

Report by the Secretariat

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REPORT ON THE ESTABLISHMENT OF THE AFRICAN NUCLEAR ENERGY COMMISSION (ANEC) FOR THE DEVELOPMENT OF NUCLEAR SCIENCE AND TECHNOLOGY IN AFRICA

1. INTRODUCTION

1. The bane of Africa today is her enormous imports: from food and beverages to drugs, from household goods and office furniture to teaching and laboratory equipment, from toys to utilities and services, from wheels and tyres to aircraft andships, and from pins to industrial machines, and all these with very little export products to back them up, and hence the huge and crippling debts. Have the Africans folded their arms in idleness? No! Indeed most Africans, men and women, toil assiduously. The major problem is that the products of African traditional technology are outdated and not being in demand, cannot be exported. The exports of Africa therefore mainly comprise natural resources and products - commodities for which they get largely unfair prices in a lopsided world economic order in which as novices African countries mostly lack the techniques, the experience as well asthe leverage to exact a fair deal.

2. The crux of the matter is that the products and services for high demand in the world today and which Africa imports, derive from modern technology. Modern technology is based on science, but Africa lacks sufficient background, knowledge and experience in both modern science and technology.

3. This decisive factor in Africa's under-development and attendant problems is now being recognized. Thus the African Heads of States in the Lagos Plan of Action conceded that Africa has the largest number of developing countries, the largest concentration of least developed countries, and is the most backward and disadvantaged in the field of science and technology for development. Appreciating the linkage between these ills, Member States were urged to adopt measures to ensure the development of an adequate science and technology base and the appropriate application of science and technology in spear-heading development in agriculture; transport and communications, industry, including agro-allied industries; health and sanitation; energy; education and manpower development; housing, urban development and environment.

4. Noting that in spite of past and current efforts most Member States still lack the necessary national scientific and technological capability and consequently remained dependent on foreign technical skills for the execution of their scientific and technological tasks, it was urged that top priority should be given to the development of human resources for the creation of a science and technology infrastructure of manpower,knowledge-skills , innovation and productive capacities to absorb and adapt imported technology, on the one hand and, on the other, to develop technology locally for the identification, exploration and exploitation of natural resources and the conversion of raw materials into semi-finished and finished goods and products.

5. In like manner, it is often emphasized that for the solution of Africa's problems of underdevelopment, it is imperative to build Africa's capability and capacity in modern science and technology.

2. NEED FOR NUCLEAR SCIENCE AND TECHNOLOGY

2.1 Introduction

6. It is the application of science and technology that transforms natural resources into goods and services for a better quality of life. But as science becomes ever increasingly multi-facetted, it breeds diverse technologies each adding its bit to better conditions of living and the advancement of the world. Therefore Africa needs to monitor these facets of modern science and technology and attempt to master the areas that can made an impact on the regions' numerous problems of underdevelopment. One such area is nuclear science and technology, which in spite of being relatively new, but with a great potential for the future, is already making considerable contributions through applications in food and agriculture, mining, water resources development, medicine, industry, electrical power, research and training, etc in its peaceful uses, whereas environimental pollution by radio-active leakage and nuclear wastes wreck havoc, on bio systems they reach and nuclear war if ever unleashed would devastate life on earth.

2.2 Food and Agriculture

2.2.1 Crop Production

7. In the African region, population is increasing at a faster rate than agricultural productivity and food production, especially in sub-Saharan Africa where the population growth rate has overtaken growth increase in food production in 35 out of 41 countries. The basis of agriculture is soil fertility, but the majority of the soils are infertile and often fragile and therefore call for careful management. Unfortunately the traditional African farming system is characterized by shifting cultivation in which the fallow period needs to be long enough for the pastures and trees to grow and fix enough atmospheric nitrogen to regenerate soil fertility. To feed the increasing population, farm lands have to be cultivated more intensively and the fallow period essential for regeneration of soil fertility can no longer be afforded. The result is steadily impoverished soil, increased erosion, desertification and decrease in crop yields, sometimes amounting to as much as 70 to 80%. Even where the country can afford the foreign currency for the importation of commercial fertilizers, they are often too costly for most farmers.

8. Another important cause of soil infertility is deforestation arising from the felling of trees for fuelwood. In the region fuelwood provides 70% of energy needs furthermore 80% of the population depended on wood for 95% of energy requirements. In a vicious circle, the capacity of the impoverished and degraded soil to produce fuelwood is greatly diminished and the depletion continues. In the African region an estimated 55 million people are facing fuelwood crisis in 1987 and perhaps up to 85 million people will experience same by the year 2000.

9. Nitrogen-15 isotope techniques are being used on studies with the ultimate aim of maximizing the fixation of atmospheric nitrogen by pastures and trees thereby regenerating soil fertility for the increased production of food and fuelwood. The same technique is being used in an attempt to diversify and maximize the role of the aquatic fern Azolla which fixes atmospheric nitrogen and boosts the yield of rice.

10. A very wide and still expanding means of increasing food production is the application of diverse nuclear techniques which may be grouped under crop improvement and mutagenesis. Generally, the seed is irradiated with gamma radiation or fast neutrons to induce mutations. The genetic changes usher numerous new species from which the varieties with desired characteristics are selected. Among the characteristics sometimes sought often are, high yield, short growth period, early maturity for harvesting, grain size, higher protein content, resistance to diseases or insects, salt water tolerance and resistance to unfavourable external conditions. This technique offers a vast opportunity to the region, and indeed developing countries, to readily modernize an almost antiquated agriculture.

11. Modern aids to agriculture like insecticides, herbicides and fertilizers are being increasingly apllied in developing countries. These have some harmful side effects as they permeate and interact with the environment affecting underground and surface water, air etc. Tracer techniques are preferred in the effort to optimize the use of these agro-chemicals and minimize the harmful effects of their residues.

2.2.2 Animal Production

12. As in the case of crop production above, nuclear techniques also play vital roles in animal production. For the improvement of reproductive efficiency, antigens are labelled with iodine-125 and antibodies are developed for each hormone and these are applied in the study of the reproductive state of the animals. With radioimmunoassay techniques, hormonal patterns in the livestock are followed and measured over the reproductive cycle. With the results it is possible to devise improvement of the reproductive efficiency.

13. Ruminants like cattle, sheep, goats, buffallo etc. constitute the mainstay of animal husbandry in the region. In their digestive tract their fibrous feeds like grass and straw are broken down and converted into products that enable them to produce milk, meat, woo or draught power. Radioactive tracing techniques have been used to study the process and analyse the digestibility and nutritive value of feedstuffs. The possibilities have been enhanced by the recent development of the "rumen stimulation technique" (RUSITEC) in Scotland popularly styled "artificial cow" enabling the studies ro be done in the laboratory without the use of a real ruminant. With these studies of the dynamics and metabolism of the ruminants' digestive system, it should be possible to select preferred local feeds, and formulate diets for faster growth, better meat, more milk or indeed any desired characteristic in the domestic animal.

14. Nuclear techniques have also been successfully used in animal health and disease control. An example is the production of vaccines against worms and other helminthic organisms. Thus nuclear techniques can play a notable role in Africa where infectious and parasitic diseases often take their toll in animal production.

2.2.3 Control of Instect Pests

15. Fortunately only about 15,000 or less of the more than one million species of insects that inhabit the world have harmful effects on plants and other animals. Unfortunately, however, they are responsible for considerable losses (about 15 to 20%) of the world's plant and animal agricultural production and the percentage is a lot higher in developing countries. These losses arise from direct damage to plants and animals; diseases of plants and animals transmitted by insects, and destruction of agricultural products during storage. In addition, human lives are lost through diseases transmitted by insects such as malaria, yellow fever, onchocerciasis, dengue etc. Prevention of food losses has become crucial for survival in Africa where population has outstripped food production and drought is endemic.

16. Insecticides developed in the last 40 years or so have been widely used in the control of these pests. These have not been completely successful because the insects gradually develop resistance to the chemicals, the chemicals pollute the environment; and some insecticides leave residues which are harmful to plants and animals including humans. Consequently, alternative methods are required for insect control.

17. Apart from the sterile insect technique which deserves separate treatment, the alternative methods include the use of insect pheromones (sex attractants) to pre-empt mating by confusing insects to prevent males and females getting together; inundative release of parasites and predators; and developing host resistance. Isotope tracer techniques play important roles in developing these methods. Radiation is also used in microbial control, quarantine treatment of agricultural commodities especially for export purposes, genetic engineering and in breeding resistant plant varieties.

18. Of major importance is the sterile insect techniques (SIT). In this technique, X-rays or gamma radiation is used to sterilize insects sexually with doses that do not adversely affect their mating and inseminating ability but the resulting eggs are sterile and produce no offsprings. This SIT is species specific. When large numbers of males are reared, sterilized and released, the population of the new generation is drastically reduced. By repeated application, the pest can be eradicated by this process that prevents reproduction.

19. A major advantage of SIT is its effectiveness in area-wide insect control. Most of the other methods are usually applied, preferably in combination, in integrated pest management (IPM) on farm to farm basis. This is too expensive for small farmers and not entirely satisfactory for the large producer as the insects persistently migrate from the neighbour holdings. In the more satisfactory area-wide control the insects are controlled at source and not at the point of their doing damage. In this way some of the more virulent major destroyers like locusts, mosquitoes and tsetse flies can be controlled at less cost to the advantage of both small and large farmers. Area-wide control is the only effective means of complete eradication.

20. Since SIT was first used to eradicate the screwworm that attacked cattle, from the Dutch Island of Curacao in the Caribbean in 1984 and to eradicate the medfly, the Mediterranean fruit fly from Mexico, it has been developed to the point of now being proven. There are now about 10 projects in which SIT is being applied to eradicate insect pests. The SIT projects tend to be large and consequently international in scope. In spite of the usually large outlay because of the wide scope, they are relatively cheap. The total cost of rearing is about $100 per million flies. A new method is being developed in which the females are killed early during rearing. Where this is applicable the cost of rearing males only can be reduced to about 60%.

21. One of the big cooperative SIT projects is the Biological Control of Tsetse fly (BICOT) in Nigeria. Apart from being dtrtimental to human the tsetse fly is the vector of nagana or animal trypanosomiasis which destroys livestock on a large scale and infests a large area (about 70%) of the agricultural land in Africa. The Nigerian SIT project, BICOT, has eradicated the target species of tsetse fly from the project area of about 1500 square kilometers in North-Central Nigeria. The Nigerian Government is requesting an expanded project BICOT II, covering an area of about 12000 square kilometers in Plateau State of Nigeria.

22. The SIT technique holds great promise of reclaiming vast areas of agricultural and grazing land of Africa from the widespread menance of the tsetse fly and other pests like the Mediterranean fruit fly. This can vastly boost food production (crops and livestock) in Africa and make considerable impact on the improvement of living conditions of the rural communities.

2.2.4 Food Preservation

23. It is worrying that while Africa faces the problem of increasing food production to feed her rapidly growing population, she suffers a staggering amount of post harvest losses of food estimated at about 25 to 30% of the annual production. This is a clear proof that the traditional and current methods of food storage and preservation fall short of the requirements and new methods are urgently needed.

24. It has long been known that exposing foodstuffs to ionizing radiation prolongs their storage life. As of now, the most popular source seems to be gamma radiation from Cobalt-60. Irradiation of foodstuffs not only prolongs their self-life but also inhibits the germination of tubers and other vegetables, controls pathogenic agents, parasites, and insects that attack them, and achieves microbial sterilization of spices and other dried ingredients. By now the irradiation technique is well-proven and has spread all over the world including developing countries.

25. Irradiated food can be wholesome food and the technique has some advantages. No heat or dehyration occurs in the process and therefore the freshness and the original physical condition of the food item (vegetables, fruits, tubers, grains, meat, fish etc.) are preserved. The foodstuff could be pre-packaged before irradiation. The process is convenient. There is however the problem of public acceptance of irradiated food.

26. There is need for a national regulatory authority to inspect and approve the irradiated food for distribution and consumption, guided by international radiation safety and protection rules and practices. In 1983 the international organization, Codex Alimentarius Commission approved standards for irradiated food. A number of countries including developing countries like Bangladesh, China, Republic of Korea, and India have approved the marketing of a wide range of irradiated food.

27. Food irradiation offers Africa an opportunity of reducing her staggering post harvest losses of food that is very much needed to feed her ill-nourished population.

2.2.5 Irrigation Water Management

28. Water is scarce in many part of Africa especially the Savannah and Sahelian regions. Irrigation becomes necessary and is often practised in these areas. Proper management of the scarce water is imperative in crop production under these conditions.

29. Whether irrigation or rain-fed agriculture is practised, nuclear techniques involving radiation and isotopes enable moisture changes in the soil, and moisture uptake by crops to be studied in a reliable and non-destructive way. By quantifying the water requirements and understanding the dynamics of water usage by crops from these studies the scarce water can be managed efficiently to maximize crop production.

2.3 Water Resources Development

30. Availability of sufficient and suitable water supply for domestic, agricultural and industrial purposes in Africa is a real problem especially in the savannah and sahelian areas. Not only natural springs but also rivers, streams, rain, lakes, water collected from roofs, shallow wells and stagnant pools often infested by worms etc. are relied upon for water supply.

31. Many national development plans include water supply schemes. Indeed, the problem is so serious that many countries establish parastatals for water resources development and water supply but too often for the urban areas only. However, even these urban water schemes need scientific and technological support to identify, quantify and exploit available water resources. Nuclear techniques have been found very helpful in the study and development of both surface and underground water.

32. In these nuclear techniques environmental isotopes which are part of water like tritium,deuterium, and oxygen-18 as well as "artificial" gamma emitting isotopes are used. So, much information can be gathered quite cheaply including those that are not available by any other means.

33. On surface water, nuclear techniques provide information on run-off from rain, flow rates of streams and rivers, suspended sediments being transported by streams and rivers, leakage and evaporation from lakes and reservoirs, seepage through dams; and the time delay between injection and detection coupled with the shape of the isotope concentration curve at the material time give precise information on the dynamics of the system.

34. For groundwater, nuclear techniques provide information on the origin of the water, qualitative differences between bodies of water, infiltrations at different climatic periods mixed in the body of water, the quantity and quality of water, direction of flow and velocity if any, recharge areas and estimates on when last recharged. A difficult but very important information for feasibility decisions is the determination of the residence time or age of an aquifer. Depending on the age, additional isotopes like carbon-14 and chlorine-36 may be used. In the end a reliable age is obtained. Indeed isotope hydrology is the best and most powerful method of investigating the occurence of groundwater recharge and identifying fossil groundwater.

2.4 Mining

2.4.1 Introduction

35. The modern world depends much on mining for raw materials which constitute the mainstay of the manufacturing industry and energy production. As mineral raw materials are not renewable it is essential to develop more efficient, time and cost-saving and energy-saving, methods of mineral exploration, extraction and processing.

36. Nuclear analytical techniques can contribute to national economies by enhancing efficiency in the exploration, extraction and processing of mineral raw materials with savings in energy, materials and operational costs. They are simple, rapid, applicable to a specific target element or multi-element situations, can produce results in almost real time, and being non-destructive can be applied in situations where other methods are not applicable.

2.4.2 Mineral exploration

37. Nuclear techniques are particularly suited for the understanding of the geology and processes in the area of interest through knowledge of the distribution of elements in, and the ages of, rocks in the area. One of the most powerful methods of determining over 40 different elements is neutron activation analysis (NAA). It is very sensitive and accurate, and capable of detecting trace elements without destroying the sample.

38. Analysis of chemical composition of plants, water, organic and inorganic sediments reveal economical mineralization in underlying rocks and the route of transport if they had been trans-located. Although concentrations are often only a few parts per million, NAA can handle the chemical composition determination rapidly and cheaply because the analysis is highly automated.

39. Uranium decays to gamma emitting as well as alpha emitting daughter nuclides. Exploration for Uranium involves measuring the gamma activity of a daughter like bismuth-214 or the alpha activity of a daughter like radon gas.

40. Following mineral or oil exploration, the determination of economic viability usually involves drilling expensive boreholes. Nuclear techniques provide several sensitive and relatively cheap methods of obtaining maximum information from the core sample or walls of the boreholes. They are capable of determining many minerals like uranium, thorium, potassium, coal, dense metallic ores, oil, gas and water etc.

41. Among the techniques are: X-ray fluorescence analyses, several borehole logging devices such as measurement of natural radioactivity either gross or spectrometrically, interaction of radiation (gammas or neutrons) from a source with the environment and the analysis of the resulting radiation yields information about the interacting medium such as its density or porosity.

2.4.3 Mineral Extraction

42. At the extraction stage, radioactivity is used to grade uranium ores and determine waste rock. To avoid mining useless rocks, nuclear, techniques are also used to determine the thickness of coal seams. Trace techniques are used to determine the rate of oil recovery especially at low pressures when fluids are injected to help force out the soil.

2.4.4 Mineral Processing

43. Tracer techniques, elemental analysis and nucleonic control systems are often used at the recovery and purification stages of ore processing of metals, oil and coal. However the most popular nuclear technique is X-ray spectrometry which provides on-line analysis of metals and can handle simultaneously the input material, the final product and the tailing, giving information on several metals at the same time.

44. Gamma ray absorption and scattering techniques are particularly useful in circumstance where non-nuclear techniques are not suitable. These include measurements of materials inside containers, filling level in storage vessels and furnaces, density of materials in flow pipes, amount of ore in a mixture flowing in a pipe, and assessment of materials on a conveyor belt. Neutron elastic scattering is quite often used to determine water content of coal.

45. In ore processing, extensive use is made of radioactive tracer techniques. Examples of radiotracer applications include finding volumes of materials in reaction vessels, following the physical and chemical reactions, separation of metal and slag, identification of non-metallic inclusions in metals, determining the wear of reaction vessels, studying bending, crushing and flow of materials.

46. The application of nuclear techniques to the various stages of the mining processes has several advantages. In addition to those already mentioned : nuclear radiation is very penetrating and can therefore provide information on a large volume simultaneously, on-the-spot enabling and on-line analyis in real-time, it is applicable in dynamic situations, as well as when the condition of the material or the geometry of the situation excludes other methods. These advantages lead to considerable financial savings.

2.5 Health and Medicine

2.5.1 Introduction

47. The application of nuclear techniques in medical diagnosis, therapy and research is quite wide. The impact of nuclear science and technology on health care and medicine has been so decisive that nuclear medicine is now one of the recognized specialised fields in medicine. Nucelar medicine techniques scientifically identify the origins of and changes during stages of disease and they constitute firm bases for therapy that lead to a quicker and fuller recovery. They range from techniques that have become the common tools of all medicine to highly sophisticated new ones. The practice is so widespread that most countries apply at least the commonest techniques.

2.5.2 Medical Diagnosis

48. The commonest technique for internal diagnosis is the X-ray. It is hard to imagine of what the state of medical diagnosis would have been without the X-ray, and yet the technique has become so common and basic to medicine that it is little remembered as a product of nuclear science and technology. More powerful nuclear imaging devices than the X-ray are now in use.

49. After a patient has taken radioactive drugs or other drugs labelled with radioisotopes, modern instrumentation uses the emissions from the radioactive materials to scan and produce an image of the target organ. While the method of scintigraphy gives an ordinary picture of the organ, the technique of tomography gives a 3-dimensional picture of the organ. In nuclear medicine, one of the most widely used radioisotopes is the metastable technetium-99m, though the technology for its production is yet beyond most developing countries. Technetium-99m radiopharmaceuticals are used in the location of tumours and diagnosis of liver and kidney diseases. Iodine-125 is also an important radio pharmaceutical.

50. Apart from the possibility of scanning organs including the brain, which was referred to above, nuclear tracer techniques are also used in studying the functioning of organs. Excretion of a labelling isotope by the kidney reveals its functioning, the volume and circulation of blood as well as absorption of vitamins can be studied with tracers; the spleen can be screened with Chromium-51, and the pancreas can be studied with selenium-75.

51. A nuclear diagnostic technique that has now assumed great importance and attained wide use is radioimmunoassay (RIA). This technique provides a simple, inexpensive technique of measuring extremely small amounts of hormones, vitamins, drugs, enzymes, some proteins, hepatitis virus, and many other substances of medical interest circulating in blood. Without the patient ingesting any radioactivity RIA uses radionuclide-labelled substances introduced into a sample of the patient's blood to study the biochemical processes of his body. The RIA has assumed so much importance that it is estimated that even in developing countries 10 to 20% of all in-patients are diagnosed with RIA, and yet the kits for its application have to be imported into most developing countries.

2.5.3 Medical Therapy

52. Sterilization is very important in medical therapy. Surgical dressings, sutures, syringes, surgical gloves, needles , catheters and many other products must be sterilized. Radio sterilization, most commonly with gamma radiation from Cobalt-60 sources, is increasingly being preferred to heat and steam treatment because of its advantages. The materials can be hermetically sealed in packages making them inaccessible to micro-organisms and

after the radiation penetrates the pre-package, the sterilization is preserved indefinitely until opened. This makes radio sterilization safer. Heat sensitive materials may be sterilized by gases or chemicals but these often give rise to undesirable residues and reactions. Radiosterilization scarcely raises the temperature of the materials and is therefore preferred for the sterilization of heat sensitive materials like plastics, medical and other biological preparations, pharmaceuticals like solutions, ointments and powders. Radiosterilization is easily automated and routinized and consequently the process is cheaper.

53. Radioactive isotopes are also used directly for the treatment of diseases. Examples are the common treatment of cancer of the thyroid with radioactive iodine and the treatment of cervical cancer by internal irradiation.

2.5.4 Environmental Health

54. There is a great and well-founded concern about the environmental pollution by the emissions of toxic gases, sulphur dioxide (SO_2) and nitrogen oxide (NO_x) into the atmosphere from coal and oil-fired boilers in electrical power plants and industrial installations. The detrimental effects are immediate and long-term.

55. The immediate effect is in a limited area but results in chronic respiratory diseases, heart and lung problems, and deterioration of the environment. The problem is really serious. One power plant of capacity 500 MW may consume 250 to 300 tons of coal per hour, and discharge tens of tons of SO_2 per hour, depending on the sulphur content of the coal (usually 0.2% to 10%). It has been estimated that in USA alone air pollution would cause in about 10,000 deaths and about 25 million respiratory disease cases per year.

56. The long-term effect of these toxic, so called flue or stack gases, would involve very large geographical areas across national frontiers. By photochemical conversion of the toxic gases in the atmosphere, sulfuric and nitric acides are produced which come down in the form of "acid rain". Acid rain devastates forests, earth flora, and acidifies lakes and dams, and has been reported in USA, Europe, and Asia.

57. In many countries including USA, Federal Republic of Germany, Austria, Switzerland, Italy, Netherlands, Denmark, Finland, Sweden, EEC, India and China, strigent regulations have been intoruced limiting the level of the flue gases, SO_2 and NO_x, to be released into the atmosphere, but their permissible levels differ from country to country. Hundred of millions of dollars are now involved in efforts to "scrub" the stack gases prior to release.

58. The conventional scrubbers remove SO_2 and NO_x in two separate processes. For SO_2, lime is used and products of little or no commercial value are produced resulting in another problem of waste disposal. For NO_x, the process of selective catalytic reduction uses ammonia reagent to convert nitrogen oxides into atmospheric nitrogen.

59. Nuclear radiation processing has now been developed to solve this crucial problem. In the presence of ammonia, oxygen, water and some other chemicals intentionally introduced, the stack gases are irradiated with an electron beam of high energy (300 to 800 KV), ionizing the gases and exciting atoms and molecules. The components of the complex quickly react forming useful byproducts. The process is simple and safe to operate and maintain, and capable of removing over 90% of SO_2 and up to 90% of NO_x. The advantage of simultaneous removal of both SO_2 and NO_x in one dry process makes it highly competitive and economically viable.

60. It should be noted that electricity generation in the African region with coal and oil is increasing and now industries are beginning to add to the release of toxic flue gases. Yet, environmental consciousness is low and regulations hardly exist presently to control the release of these very damaging gases.

2.6 Industry

2.6.1 Introduction

61. Nuclear science and technology provide a multitude of industrial applications, so numerous that it is impossible to enumerate them in a brief report. Nuclear techniques benefit most industries. The applications are not only numerous but diverse, and often one technique is capable of serving several purposes. Consequently, it is not easy to devise an effective scheme for categorizing them.

62. In term of process, three classes may be recognized. In one class, the radiation suffers varying attenuation on passing through the material of interest and the appropriate sensing of the output radiation provides an image or a scanning of the material. In the second class, radiation from a sealed source or form an isotope taking part in the process (a tracer) gives rise to certain physical signals which can be measured to monitor properties of interest. In the thrid class, the radiation is just a source of energy that induces specific physical, chemical or biological changes resulting in desired properties in the material receiving the energy.

63. Many radioisotopes act as the source of radiation in processes to which they are particularly suited. The most popular source is Cobalt-60 installed in about 140 industrial facilities. The radiation may be produced by a separate process organised for that purpose as in the simple case of X-ray from X-ray tube. The separate process may however be complicated as in the production of an electron beam (EB) from an accelerator

64. For any industrial application, certain electron beam factors must be considered for an appropriate choice of the radiation, its source and mode of deployment. These include, energy of the radiation to ensure adequate penetration into the material; charge of the radiation which affects penetration; power to ensure adequate throughput; intensity for adequate rate of reaction; efficiency; process control; reliability; and safety.

65. In tracer techniques these factors present little or no problem because they are so many isotopes to choose from. Almost all industries can benefit from the tracer technique. The field and applications are so wide that IAEA is preparing a guidebook on the applications of radioisotope tracers in industry.

2.6.2 Radiography

66. In radiography the varying attenuation of radiation on passing through the test materials is appropriately scanned e.g. with appropriate emulsion of a photographic film receiving the output radiation. X-rays and gamma radiation are used to check welds, castings and ceramics. In other circumstances neutron absorption is used for detection of voids and undesired inclusions as in rocket propellants. The process is non-destructive.

2.6.3 Autoradiography

67. Autoradiography works on the same principle as radiography but in autoradiography the source of the radiation emitted is part of the test material. The sample material is either a natural emitter of radiation or a radioisotope intentionally incorporated in it. This may be used for checking for faults in castings, ceramics and vital parts of industrial machines and equipment. In other situations, it is used for detecting the localization of particular compounds and elements in parts of plants or organs of animals.

2.6.4 Detection of Faults

68. A major use of the tracer technique is in the detection of faults. These include: detection of leakage in oil and other fluid carrying pipes; location of blockages in pipelines; leakage in undergound well and storage tanks, wear inside engines and blast furnaces; rusts and corrosion inside boilers, leakage in semi-conductors; etc. Tracers also monitor leakage in heat exchangers.

2.6.5 Sterilization, Disinfection and Curing

69. Gamma radiation, mostly from cobalt-60 is used in sterilization of many industrial products especially when bulky and or prepackaged. It has also been used for disinfection of sewage, sludge and curing of wood-plastic

composites. The application of electron beams (EB) is limited to thin materials because of the very shallow penetration. EB is used for curing of coatings on paper, film, wood, plastics, metal etc.; EB have also been used for disinfection of grains and decontamination of animal feed.

2.6.6 Industrial Gauges

70. Nucleonic gauges are able to measure level, thickness and density. They are usually applied in difficult situations where the use of conventional gauges are not possible or convenient. They have been applied to measure and monitor the level of liquid in a sealed opaque container; the thickness of a moving sheet in a production line; the wear in cutting tools; the density of a corrosive medium; or the density of a fluid at very high temperature inside a furnace. Radiation gauges are also used to control the process of filling packages and tubes, for example: tobacco in a stick of cigrarette, toothpaste in a tube, and the filling of liquids and powder in similar circumstances.

2.6.7 Quality Control

71. Radiation techniques are ideal for quality control and scores of thousands are in use in many industries. Nucleonic gauges are used to optimize quality in industries producing sheets of materials. In the paper industry, they continuously monitor the paper weight per unit area and in steel industry they monitor thickness of steel. In other situations, quality is ensured by use of tracers to monitor mixing efficiency and particle size distribution.

2.6.8 Measurement in Dynamic Processes

72. Tracer techniques are particularly convenient and are widely used for measurement and monitoring in dynamic situations. Examples include flow rates, branching ratio, by passing, two phases flows, diffusion, permeation and dynamics of migration. Others include oil consumption in industrial plants, mercury inventory in electrolytic cells, off-shore sand and sediment studies in harbours, silt movement, sand drift studies, and kinetic studies.

2.6.9 Cross-linking and Grafting

73. Electron beam (Eb) has found many uses in cross-linking and grafting. Low energy EB is used for cross-linking thin wire insulation, polyethylene film to produce heat shrinkable film for packaging, thin plastic film. High energy EB is used for cross-linking plastics e.g. wire and cable insulation (polyethylene and polyvinylchloride i.e PVC), heat shrinkable materials, hot water polythylene pipes, foamed polyethlene (used for thermal insulation, crash padding, floating jackets, floor mats etc). Gamma radiation has also been used in grafting for battery separators.

2.6.10 Polymerization

74. Gamma radiation is used for polymerization and for the improvement of woodplastic and wood polymer composites. High energy electron beam is also used for modification of bulk polymers.

2.6.11 Industrial Material Processing

75. In addition to cross-linking, grafting and polymerization, radiation is also used in some other indutrial processes. Gamma radiation is used for vulcanization of rubber latex. High energy electron beam is also used in vulcanization of rubber; and in the production of high liquid absorbent materials which have resulted in products like tampons, diapers and air-freshner elements.

2.7 Electricity Generation

2.7.1 Need for and Supply of Electricity in Africa

76. The strong connection between economic growth and energy consumption is very well known and is genrally demonstrated by the very high energy consumption per capita coupled with high standard of living in industrialized countries as compared with the small energy consumption and low standard of living in most developing countries. Therefore there is no gainsaying the fact that for economic and social development, reliable and economical energy supplies must be available.

77. To illustrate, with less than 5% of the world population, the USA in 1985 consumed 25% of the total world energy production, an average of about 320 GJ per capita, as compared with about 200 GJ average consumption per capital for all industrialized countries. The entire developing world, with 75% of the world population, in the same 1985 consumed only about the same amount of energy as USA, an averace consumption of less than 25 GJ per capita!

78. Nearer home, a similar comparision holds. In 1978 South Africa was responsible for 54.8% of all the electricity produced, and 58.1% of all the electricity consumed in Africa.

79. The connection between electricity consumption and socio-economic development is even stronger. Statistics demonstrate a linear realtionship (direct proportionality) between increase in electricity consumption and growth in GDP in the OECD countries from 1970 to 1987. That statistical study is instructive because it showed that while the oil price shocks of 1973 and 1979 diminished the strong connection between primary energy consumption

the very strong connection between electricity consumption and GDP was not impaired. Therefore, for a higher socio-economic growth, Africa must increase the production and consumption of energy in general, but of electrical energy in particular. Any talk of closing the gap between the industrialized and developing countries would seem to demand a higher rate of increase in the production and consumption of electricity in the developing than in the industrialized countries.

80. In the face of this dire need for a highly accelerated increase in the production and consumption of electricity in Africa, a 1983 study by ECA revealed a dismal picture. During the period 1970-1978, electricity consumption per capita in developing Africa, grew at the rate of 4.6% per annum. During the second half of the 1970s, the growth rate dropped to only 2% per annum as a consequence of increasing energy prices and increasingly difficult domestic conditions which led to substantial decrease in industrial activities. Adopting a historical trend also showed that electricity production could be increasing at a rate of about 7.4% per annum between 1978 and 2008.

81. ECA concluded that if historical trends continued, even the projected moderate potential demand based on 1978 consumption trends might not be met by the projected supply. The ECA study then iferred:

> "The above projections of electricity production show that, unless developing African countries increase and diversify their productive capacity, the relatively moderate projected historical demand would have to be substantially curtailed to match available supply. The frustrated demand by 2000 would amount to 135,667 GWh or twice the total electricity consumption in 1978. The implications of such a situation are quite disastrous as: (i) an increasing number of households would have to live much below the minimum standard of living. (ii) rural electrification would be seriously jeopardized as would, in consequence, productivity in the agricultural sector and (iii) a growing number of industrial activities would continue to be negatively affected by energy shortages. Indeed, if actual consumption in 2008 would have been limited to available supply, the level of per capita consumption in 2008 would be only 561 KWh/person, which corresponds to the 1979 per capita consumption of the Libyan Arab Jamahiriya".

82. Yet the above projection of demand has not taken into account the obvious need to replace firewood with other sources of energy such as electricity which will make additional demand on electricity supply. According to an ECA review, in 1978 firewood accounted for 85 MTOE representing 70% of the total energy needed in Africa. Unless the domination of energy supply in Africa by firewood is reduced, great damage would be done to agriculture, forestry resources, and ecological balance, and increasing problems of erosion and desertification would be created.

2.7.2 Nuclear Power Today

83. According to IAEA, nuclear power in developing countries today contributes only about 3% of their total electricity production, compared with about 18% for industrialized countries, and a world average of 15.5%. It should be instructive to Africa to see the situation in terms of individual countries and consequently the following three tables are reproduced from IAEA statistics.

Table 1: Nuclear Share in Per Cent of Electricity Production in 1986

(Source : IAEA Pris)

France	69.3	United Kingdom	18.4
Belgium	67.0	United States	16.5
Sweden	50.3	Canada	14.7
Taiwan	43.8*	Germay, Dem. Rep.	11.6*
Korea, Rep. of	43.6	Argentina	11.3*
Switzerland	39.2	USSR	10.0*
Finland	38.4	South Africa	5.8
Bulgaria	30.0	Netherlands	6.2
Germany, Fed. Rep.	29.4	Yugoslavia	5.4
Spain	29.4	Italy	4.5
Hungary	25.8	India	2.7
Japan	24.7	Pakistan	1.8*
Czechoslovakia	21.0*	Brazil	0.1

84. For the world as a whole the nuclear electricity generation as a percentage of the total electricity generation has steadily increased from 0.1% in 1960, to 0.7% in 1965, to 1.6% in 1970, to 5.5% in 1975, to 8.5% in 1980, and 397 nuclear power reactors operating in the 26 countries above provided 1,514.6 TWh or 15.5% of the world's electricity in 1986.

Table 2: Distribution of Installed Nuclear Generating Capacity in the World, 31 December 1986
(Source: IAEA PRIS)

Industrialized Countries: 92.9%

USA	39.9%	Spain	2.2%
France	16.3%	Belgium	2.0%
USSR	10.1%	Switzerland	1.1%
Japan	9.4%	Finland	0.9%
German Fed. Rep.	6.9%	South Africa	0.7%
Canada	4.1%	German Dem. Rep.	0.6%
United Kingdom	3.7%	Italy	0.5%
Sweden	3.5%	Netherlands	0.2%

Developing Countries: 7.1%

Korea, Rep. of	2.0%	India	0.4%
Taiwan	1.0%	Argentina	0.3%
Czechoslovakia	1.0%	Brazil	0.2%
Bulgaria	0.6%	Yugoslavia	0.2%
Hungary	0.5%	Pakistan	0.1%

35. It should be noted that no African Country qualified for a place in Table 3 where 4 of the 10 developing countries are from Asia and 2 from South America. Even when plants under construction are included in Table 4, Africa is still absent.

Table 3: Nuclear Power in Developing Countries 31 December 1986

(Source: IAEA PRIS)

	Reactors in Operation		Reactors under Construction	
	Units	Total Capacity MW (e)		Total Capacity MW (e)
Argentina	2	935	1	692
Brazil	1	626	1	1 245
Bulgaria	4	1 632	2	1 906
China			1	300
Cuba			2	816
Czechoslovakia	7	2 709	99	5 500
Hungary	3	1 235	1	440
India	7	1 154	4	880
Iran				2 400
Korea	7	5 320	2	1 800
Mexico			2	1 308
Pakistan	1	125		
Poland			2	880
Rumania			3	1 320
Taiwan	6	4 918		
Yugoslavia	1	632		

86. However, the Chernobyl nuclear accident on April 26, 1986, in USSR has increased the resolve of the opponents of nuclear power. On the other hand, the nuclear industry continues to demonstrate that the risk from nuclear power is not greater than the risk from other industries and points at the Bhopal chemical accident on December 17, 1984, in India that released poisonous gas. More importantly, the Chernobyl accident has led to international co-operation for tightening safety measures in the nuclear industry. It also rekindled the discussion on a new design of inherently safe or "fail-safe" reactors that would not require any action of the operator to shut down when anything goes seriously wrong. A recent case in Canada when a serious nuclear accident was averted when a 500 Mwe reactor shut itself down on the failure of a pressure tube vindicates the case for new designs.

2.7.3 Approach to Nuclear Power

87. In Section 2.7.1 above, a strong case has been made for a large increase in electricity supply in African countries. Such a need can only be satisfied by an optimal mix of electrcity generation from diversified primary energy sources. However, energy resources are not evenly distributed in Africa. Much of the petroleum resources are in North and West Africa, hydro-electric resources in Central Africa, geothermal potential along the Rift Valley in East Africa, and coal deposits in Southern and South-Eastern regions of the continent.

88. Although crude oil and natural gas accounted for 44% of Africa's commercial energy consumption in 1980 and projections indicate that this share might grow 67% by 1990, only eight countries in Africa are net exporters of oil, namely: Algeria, Angola, the Congo, Gabon, the Libyan Arab Jamahiriya, Nigeria, the United Republic of Cameroon, and Zaire. For the large majority of African countries oil import ranges from 26% to 86% of the commercial energy requirements. Consequently, the oil import bill has crippled development in many African countries. The poorest in the world, these countries can hardly afford to allocate 60 to 70% of their foreign exchange resources to pay for oil.

89. For most African countries, therefore, there is need to replace oil as much as possible. On the wave of the Nairobi Programme of Action, renewable energy resources had been advocated as the widespread solution to Africa's energy problems, but in many cases the credibility of these new technologies had suffered from their premature and excessive promotion in Africa. Indeed, a senior expert group appointed by IAEA in 1986 was of the view, that in contrast to the proven status of nuclear power, the present technical and economic uncertainties surrounding solar power, wind power, biomass, etc., do not permit dependence on them for large scale electricity generation in the foreseeable future although they could play a role in supplying electricity in villages and remote areas not connected to centralized grids. They therefore concluded that only nuclear power with the highest practical reliability and safety standards and coal based power with suitable environmental protection standards, could become significant substitutes for oil in the generation of the large amounts of electricity necessary for general socio-economic development in developing countries. It should be noted that in the generation of electricity, the fuel cost for a nuclear power plant can be as low as only one third the fuel cost for an oil-fired, one half of that for a coal-fired plant, assuming plants of equal generating cost.

90. However, we have seen from section 2.7.2 above, that only about 25% of the countries engaged in nuclear generation of electricity in 1986 belong to the developing countries of Asia and Latin America and none yet from Africa. The major reasons are the very serious constraints on a developing country wishing to engage in nuclear power production. The wide ranging constraints include lack of: government and national commitment, organizational and regulating basis for radiation

protection, adequate size of electric grid, public acceptance, national supporting infrastructure, qualified manpower, technical and scientific development, industrial support structure, adequate institutional structure for nuclear programmes, national quality assurance quality control system, international agreement structure for supplies and transfer of technology arrangements for equipment, fuel, services, spares and technology on a continuing basis, adequate and supportable financing, and worthiness for large credits. The IAEA has consistently given guidance to member States on the initiation of nuclear power production, in the course of which it has developed three packages: Model for Analysis of Energy Demand (MAED), Wien (Vienna) Automatic System Planning (WASP), and Energy and Nuclear Power Planning (ENPP).

91. In February 1986, the IAEA established a Senior Expert Group (SEG) of 20 participants from 15 member States plus the World Bank: to identify and analyze the problems of and constraints on nuclear power introduction and expansion in developing countries; and to study mechanisms for dealing with the identified problems and constraints in order to assist developing countries with the promotion and financing of their nuclear power programmes. The report of the SEG has been published by IAEA in August 1987 as STI/PUB/777. Every developing country wishing to engage in nuclear power production is strongly advised to avail itself of the wealth of information and guidance in this publication.

2.8 Training, Research and Development

92. The activities of a nuclear research and training centre depend on certain facilities like: gamma source, neutron generator, particle accelerator, and nuclear reactor. These are all sources of nuclear radiation.

93. A gamma source, like cobalt-60 produces gamma radiation for gammagraphy and irradiation of samples, many examples of which have been cited above. A neutron generator generates neutrons for irradiation of samples usually in neutron activation analysis (N.A.A.). When fast neutrons irradiate many elements nuclides of short half-lives are produced usually by (n,x), (n,2n) and (n,γ) reactions. From the automatic analysis of the products, a multichannel analyzer plots a chart from which the elements in the sample can be identified and their amounts accurately determined. This very powerful non-destructive tool is based on the characteristic half lives of the product nuclides and their rates of decay.

94. A particle accelerator accelerates nuclear particles to high energies. In using these to bombard targets, the interaction produces other particles often involving transformations or sometimes by pair production entirely new particles predicted by theory.

95. A nuclear fission reactor is a device in which controlled chain reaction occurs. There are several types of reactors which need not concern us here. Most reactors are nuclear thermal reactors in which thermal neutrons induce the fission of uranium isotope (U-235). On the average the product is 2.5 fast neutrons and two fragments lighter than U-235. The fission fragments copiously emit diverse radiations especially electrons and gamma rays. Thus the reactor is a veritable source of diverse nuclear radiations of varying energies. These radiations can then be used to produce radioisotopes, and in principle be used for the same purposes as radiations from gamma source, neutron generator and particles accelerator though the geometry of the reactor may make it less convenient for certain purposes. The enormous heat produced by fission can be used to generate electrcity as in nuclear power reactors.

96. All the applications to agriculture, industry and so on, outlined in the above sections are based on the radiations produced by these facilities of a nuclear centre. It is therefore pointless listing the research and development that can take place in a nuclear research centre. In the first place all the applications have been developed as a result of research and the research continues.

97. Almost all industries, science and technology can benefit from nuclear techniques. Since the nuclear reactor can produce all the usual radiations, isotopes and heat which are the primary ingredients in the nuclear techniques most industries, science and technology can benefit from a nuclear reactor. Consequently, the research around a reactor is widely multidisciplinary. In addition to administrative and service departments, a nuclear centre with a reactor normally has research departments of Physics, Chemistry, Biology, Radiation, Protection and Safety, but depending on orientation, there may be additional departments like Food and Agriculture, Geology and Mining, Radioisotopes, Mathematics, Metallurgy and Materials Science, Electrical Power Engineering, etc. Each may have its laboratory but deploy its on-line equipment in the reactor hall if and when necessary. The reactor can also be modified to change emphasis or for up-grading.

98. The reactor provides an ideal environment for training in the nuclear field. All aspects can be available in the same place all engaged in a co-operative endeavour. The versatility of the reactor is a great asset.

3. ASSESSMENT OF THE SITUATION IN AFRICA

99. Section 2 has provided a brief review of the areas in which nuclear science and technology (NST) can promote the socio-economic development of the African region. These cover those areas including basic needs: Food and Agriculture; Water Resources Development; Mineral Exploration, Extraction and Processing; Health and Medicine; Industry; Electricity Generation; and Training, Research and Development. Hardly any other new development in science and technology can match the versatility of NST in practical applications in so many diverse areas. This almost unique characteristic arises from the truly multidisciplinary of NST.

100. Arising from its multidisciplinary nature, NST provides opportunity for co-operation between scientists, engineers, technicians, agriculturists, medical doctors, industrialists as well as economists and lawyers (on large-projects). Thus it provides an excellent environment for training and technological transfer in which the trainee appreciates co-operation and the value of a multidisciplinary approach to the solution of a problem.

101. So far Africa has made relatively little progress in this very important field. Facilities are few. The major facility, a research and training reactor is operating in only three countries outside South Africa - a 1[illegible] TRIGA Mark 2 Swimming Pool reactor at Kinshasa in Zaire; a 2 [illegible] Tank Type research reactor at Inchass near Cairo in Egypt; and a 10 [illegible] Swimming Pool reactor at Tripoli in Libyan Arab Jamahiriya. Construction has stopped long ago at a site in Accra, Ghana, for a 2[illegible] Swimming Pool research reactor. In the same vein a number of expensive pieces of equipment imported into Africa for NST are not functioning.

102. An example of unrealized hopes and projections in the area of NST is in nuclear power plants. In a paper prepared by IAEA for the ECA meeting in Accra, Ghana, 1-12 March 1976, it was projected that nuclear power plants would be operating in certain named African countries as follows: in one country by 1983, in three countries by 1984, in four countries by 1985, in six countries by 1987, and in nine countries by 1[illegible]3; by which time there would be a total of 25 reactors producing about 5[illegible] MW (e). In its energy review prepared for the Joint OAU/ECA Meeting of African Experts on Energy at Addis Ababa, 24-28 March 1980 the ECA secretariat projected that nuclear power plants could be operating in named African countries outside South Africa as follows: in one country by 1983, in two countries by 1984, in four countries by 1987, in five countries by 1988, in eight countries by 1989, and by 1990 a total of 20 reactors producing 6900 MW (e). In the Energy Review in Africa of 30 December 1985 the ECA secretariat again projected that by 1990 about 1% of the electricity consumed in Africa will come from nuclear power plants.

103. There is no doubt that these projections of nuclear power plants in Africa were based on sound reasoning and calculations. The real situation is however different. No nuclear plant is operating in Africa (outside South Africa) in 1987 and as far as is known, none is under construction. Since the construction of such a plant might take more than three years, it is unlikely that any such plant will be operating by 1990. In contrast, it should be noted that of the other regions of the developing world: in Latin America three nuclear plants are operating in two countries and three plants are under construction in three countries; in Europe 15 plants are operating in four developing countries and 17 plants are under construction in five countries; in Asia 20 plants are operating in four developing countries and seven plants are under construction in three countries; in the Caribbean two plants are under construction in one country; and in the Middle East two plants are under construction in one country. The situation in the African region calls for urgent remedy. It should however be noted that according to IAEA, Egypt has planned for two plants each of capacity 1000 MW(e) and Libyan Arab Jamahiriya has also planned for two plants of total capacity 616 MW(e).

104. The great difference between the progress made in NST in other developing regions and the lack of much progress in Africa exists not only in the area of nuclear power but also in other areas of NST. Table 1, charting the activities of developing countries in Asia and Pacific region in the area of industrial applications belittles similar activities in Africa. The situation is similar in other areas like food and agriculture as well as health and medicine.

105. The nature of nuclear science and technology necessiates co-operation between scientific disciplines as well as between nations. The United Nations has always emphasized international co-operation in the peaceful uses of nuclear energy. It recently convened at great expense, a very important world conference in Geneva, 13 March to 10 April 1987, for Promotion of International Co-operation in the Peaceful Uses of Nuclear Energy (UNDESCOPUNE). Even the leading industrialized nations (including USA and USSR) are cooperating in NST in areas like nuclear safety, thermonuclear fusion, etc. The IAEA is the focus of the international co-operation efforts.

106. In the developing regions of Asia and the Pacific as well as Latin America the value of Regional co-operation is appreciated and is being exploited to great advantage. In each case the focus is a kind of regional co-operation arrangement between all the countries on the one hand and IAEA on the other. In the case of Asia and the Pacific, it is the IAEA's Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific (with the acronym RCA); and in the case of Latin America it is the IAEA's Regional Co-operative Agreement for the Promotion of Nuclear Science and Technology in Latin America (with the acronym ARCAL). These regional co-operations must have played an important part in the impressive progress in NST made in these two regions.

107. The lesson from all the above is the urgent need for co-operation in the African region. The focus for the co-operation should take advantage of the experience gained from ECA and AFCAL. The regional co-operation should foster NST in Africa and provide the fillip to force its pace of progress.

108. Given the experience of ECA and AFCAL and the peculiar circumstances of Africa, it is being proposed that the focus for regional co-operation in NST in Africa be provided by an organization to be called the African Nuclear Energy Commission (ANEC) under ECA with the active participation of IAEA and UNIDO; and as specific programmes and projects many dictate, with the involvement of FAO, UNEP, UNIDO, UNESCO, etc.

6. MANDATE AND LEGISLATIVE AUTHORITY FOR THE ESTABLISHMENT OF THE AFRICAN NUCLEAR ENERGY COMMISSION (ANEC)

109. Among the mandates and legislative authorities for the establishment of the African Nuclear Energy Commission (ANEC) is the ECA Conference of Ministers Resolution 305(XIII) which approved the establishment of policies and strategies for the development and optimum utilization of energy resources in Africa, as well as the development and utilization of non-conventional and new sources of energy. In this regard mention may be made of the Lagos Plan of Action Chapter VI on energy; the General Assembly Resolution 35/54 approving the implementation of the Lagos Plan of Action; and the General Assembly Resolution 35/56 on the Strategy for the Third UN Development Decade requesting developed countries to facilitate the fullest possible access by developing countries to scientific and technological processes to enable them to develop energy resources, including nuclear technology for the production of energy to satisfy their energy needs.

110. The meeting of experts from the African region at Addis Ababa, 1-4 July 1985 in preparation for the UN Conference for the Promotion of International co-operation in the Peaceful Uses of Nuclear Energy (UNICPICPUNE):

(i) considered that international co-operation in this field was indispensable;

(ii) took note of General Assembly Resolution 32/50 that the use of nuclear energy for peaceful purposes was of great importance for the economic and social development of many countries;

(iii) drew particular attention to paragraph 77 (f) of the Lagos Plan of Action (LPA) which recommended that:

"During the 1980's the strategy for the developing countries of Africa in their natural resources development, should aim at working closely with the international community and other non-African agencies involved in natural resources development of the region, so that external resources are directed principally to natural resources development projects which promote and sustain co-operative arrangements among Member States so as to enable the region to obtain the fullest possible development benefits flowing from regional linkages"; and,

(iv) drew particular attention to paragraph 293 of LPA on the utilization of nuclear energy; (a) calling for the training of the necessary technical cadre and encouragement of research so as to follow technological developments in the field and be able to make the right choice when the time comes; and (b) also calling for using the uranium produced in Africa as a source of energy by building nuclear power stations in the form of joint projects among neighbouring countries in view of the size of the plants which would probabaly be available;

(v) and drew particular attention to paragraph 294 (i), (c) of LPA recommending:

"Promotion of the establishment of an African Nuclear Energy Agency with a view to following up development in nuclear technology, formulating and harmonising nuclear energy development programmes in Africa and providing manpower training in the nuclear field";

(vi) and suggested in their paragraph 55(5) of their report that:

"ECA, in co-operation with other international organizations concerned such as FAO, IAEA, WHO, UNDP and relevant financial institutions should play an active and effective role in mobilising financial and technical resources, and in organizing co-operative efforts in support of Member States in the initiation and expansion of activities related to nuclear power and other nuclear applications for economic and social development in the region";

(vii) and finally recommended:

"The establishment of an appropriate international mechanism to ensure proper and effective coordination and co-operative activities as well as to review and monitor progress and provide the necessary guidance and policy directions in the implementation of the measures aimed at promoting international co-operation in the peaceful uses of nuclear energy for economic and social development".

112. In addition, the ECA Conference of Ministers Resolution 572(XX) requested the Executive Secretary, in collaboration with the executive heads of the relevant bodies and specialized agencies of the United Nations System:

(a) To lend their full support to the creation of an association of African nuclear scientists;

(b) To provide technical and financial assistance to inter-African projects on the introduction of nuclear technology in various socio-economic sectors;

(c) To assist African countries to master nuclear science and technology; and

(d) To involve African countries in nuclear research and development activities from the onset, rather than merely providing them with finished nuclear technology."

113. The approved Programme Budget for 1986-87 biennium and the Energy Work Programme for 1986-87 for ECA, include the convening of a meeting of Government Plenipotentiaries for the establishment of the African Nuclear Energy Commission (AFNEC). The scientists would also take this opportunity to meet to consider the formation of an Association of African Nuclear Scientists for which they had asked for the assistance of ECA.

114. There has been some consultation between ECA and IAEA on the establishment of AFNEC.

115. It remains to add that the terms of reference of ECA in section (8) allows ECA to assist in the formulation and development of co-ordinated policies as a basis for practical action in promoting economic and technological development in the region; and section (3), empowers the Commission, after discussion with any specialized agency concerned, to establish such subsidiary bodies as it deems appropriate for facilitating the carrying out of its responsibilities.

116. It is therefore in order to establish AFNEC as a subsidiary body of ECA with the active and effective participation of IAEA and UNDP. The ECA may maintain a small co-ordinating secretariat and cover grassroot liaison with the Member States of the region. The IAEA may provide expertise and support for programmes; and with representation in AFNEC, the IAEA would be enabled to report to its appropriate bodies. UNDP should be represented in AFNEC to enable it to participate in the deliberation, consideration, approval and support of development programmes and to report to its appropriate bodies. The FAO UNESCO, UNIDO and WMO may support specific programmes and projects of AFNEC in their fields of operations.

5. OBJECTIVES AND FUNCTIONS OF THE AFRICAN NUCLEAR ENERGY COMMISSION (AFNEC)

5.1 Introduction

117. The African Nuclear Energy Commission (AFNEC) will provide a regional focus that will enable Africa to derive the development benefits flowing from regional linkages. Some programmes are essentially regional and once the AFNEC is established it will facilitate their being undertaken. A regional programme benefits from collective strength and external bodies encouraging them to get involved.

118. With AFNEC as a regional linking focus the critical mass of human and material resources necessary for certain projects is achieved quicker. This will enable Member States to join forces and accelerate their progress in socio-economic development. Indeed some countries may be too small to have a viable Atomic Energy Agency with meaningful activities. AFNEC should enable them to participate and reap the benefits of nuclear science and technology.

119. AFNEC will foster greater sharing of resources within the region including manpower, facilities and equipment. This will provide opportunities to scientists for greater pooling of knowledge, better communication and collaboration. Consequently, brain drain outside Africa will be minimized. In short, south-south cooperation (TCDC) will be greatly enhanced and socio-economic development boosted.

5.2 Objectives of AFNEC

120. The objectives or policy considerations governing the establishment of AFNEC include:

1. To provide a focal point for the acquisition and transfer of technology in the field of nuclear science and technology in the African region, making it possible to achieve a steady development of African capability in nuclear science and technology.

2. To formulate and harmonize policies and plans for nuclear science and technology development in Africa.

3. To formulate and harmonize policies and strategies for the development and optimum utilization of nuclear energy resources in the region towards the achievement of self-reliance and self-sustaining economic growth of Africa.

4. To provide guidance and policy direction for the exploitation of nuclear techniques in furtherance of socio-economic development of the African region.

5. To foster cooperative endeavours and projects at the international, regional, subregional and neighbourhood levels to ensure viability of nuclear development programmes.

6. To mobilize financial resources not only from the United Nations system but also from financial institutions, donor countries and agencies foundations and industries for the achievement of the objectives of AFEC.

7. To enhance the socio-economic development of Africa in whatever way possible through nuclear science and technology.

5.3 Functions of AFEC

121. The functions of the African Nuclear Energy Commission include:

1. To develop manpower generally but in particular attend to the acquisition of specific and specialized skills and techniques in the nuclear field through training courses, workshops, study visits, attachments, fellowships exchanges etc., as far as possible utilizing available high quality facilities in the region in the interest of optimizing the benefits of such facilities through cooperation among the Member States.

2. To assist in the acquisition, expansion and maintenance of facilities including the encouragement of local assembly, design and fabrication of equipment and to facilitate access to facilities existing in the region for the benefit of Member States.

3. To assist in the development of the nuclear power industry from the exploration for nuclear materials to the installation of nuclear power plants for electricity generation, encouraging joint projects where necessary to hasten the contribution of nuclear power to the accelerated electricity supply needed for rapid socio-economic development of the region.

4. To promote the development and application of nuclear techniques to the solution of the problems of underdevelopment of Africa especially in the fields of food and agriculture, water resources development, mining, health and medicine, and industry.

5. To propose regional projects that will harness cooperative effort, as well as joint projects in which the weaker may benefit from the stronger country thereby enhancing even development of the region.

6. To maintain a full up-to-date inventory of the human and natural resources, and facilities in the nuclear field available in the region.

7. To maintain a full documentation of nuclear science and technology provide necessary information to research and development workers in the fields and disseminate essential information on the activities in nuclear science and technology in the region.

8. To manage the financial resources of AFNEC in such a way as to achieve the maximum possible development impact.

9. To review and monitor progress in nuclear science and technology in Africa from time to time so as to strengthen weak points and accelerate progress.

6. ORGANIZATIONAL STRUCTURE

6.1 Introduction

122. As stated in the work programme of the ECA for the biennium 1986-87, the ECA is expected to organize a meeting of African Plenipotentiaries on the establishment of an African Nuclear Energy Commission. Resolution 572 (XXI) of the ECA Conference of Ministers recommended that emphasis should be placed more on Africa acquiring the basic knowledge of nuclear science and technology and being involved from the start in the development of nuclear science and technology, rather than merely receiving the finished nuclear technology. As the emphasis is now being placed on nuclear science and technology rather than energy production, it is suggested that the body to be established for the development of nuclear science and technology should be a simple organization. Such a body could be a committee of experts called a "Technical Advisory Committee on Nuclear Science and Technology" (TAC on NUST) rather than an African Nuclear Energy Commission. This suggestion for a simpler and more pragmatic approach has been proposed.

6.2 The Secretariat of the Technical Advisory Committee

123. In accordance with the wishes to promote international cooperation in the promotion of peaceful uses of nuclear energy through existing institutions, it is proposed that the ECA should establish this programme within its existing structures. The activities of TAC on NUST will be organized by the Natural Resources Division of the Economic Commission for Africa through its science and technology and energy programmes. It will be necessary for ECA to work out a working relationship with the IAEA, which is the specialized agency for nuclear energy, and which can provide inputs for the NUST programmes to be formulated by TAC on NUST.

However, in order to provide some minimum capacity within ECA to coordinate the technical programmes in nuclear science and technology in Africa, an expert in nuclear science and technology will be required. If the regular budget cannot provide one, it will be necessary to explore the possibility of extra budetary sources of funding.

124. The responsibilities of the expert in nuclear science and technology:

1. To service the Technical Advisory Committee on Nuclear Science and Technology (TAC or NUST).

2. To prepare programmes and projects for the consideration of the Technical Advisory Committee.

3. To propose policies and strategies for the consideration of the Technical Advisory Committee.

4. To prepare, present and preserve papers, records and minutes of the Technical Advisory Committee.

5. To keep in touch with, and foster the activities of member States in nuclear science and technology.

6. To interact with and provide the link between African programmes and external national, regional and international bodies and report to the appropriate authorities of ECA and IAEA.

7. To develop documentation of nuclear science and technology and provide information to research and development workers on request.

8. To disseminate information on the activities on nuclear science and technology.

9. To provide advisory services on nuclear science and technology to member States on request.

6.3 The Technical Advisory Committee on Nuclear Science and Technology (TAC or NUST)

125. As a committee of experts for detailed technical considerations, there is need to limit the size of the Technical Committee to ensure effectiveness while maintaining geographical spread. For this purpose four sub-regions are considered:

(a) The North Africa sub-region within the area of coverage of the NULPOC centre at Tangiers;

(b) The West Africa sub-region within the area of coverage of the NULPOC centre at Niamey;

(c) The Central Africa sub-region within the areas of coverage of the NULPOC centres at Yaoundé and Gisenyi; and

(d) The East and South Africa sub-region within the area of coverage of the NULPOC centre at Lusaka.

126. The Technical Advisory Committee should include experts nominated by the ECA from 4 sub-regions. In nominating the experts preference should be given to the major nuclear centres. A nuclear centre having a reactor in operation is considered a major nuclear centre. Where there are more major nuclear centres than the number of experts expected from a sub-region, ECA should invite two of the major nuclear centres each to recommend an additional expert from within the sub-region . The same courtesy of recommendation should be extended to the lone major nuclear centre in a sub-region where there is only one such centre. Otherwise the nomination of experts should be on the consideration of personal merits.

127. Membership of the Technical Advisory Committee comprises:

Representative of ECA
Representative of IAEA
Representative of UNDP

2 experts nominated by ECA from each of the 4 sub-regions designated for the purpose.

1 expert from each of the major nuclear centre.
Representative of African Regional Centre for Technology (ARCT).
Representative of the African Institute for Higher Technical Training and Research (AIHTTR).

The ECA may invite an expert capable of making expert contributions to specific item(s) on the agenda of a meeting to participate at the meeting.

128. The terms of reference of the Technical Advisory Committee are:

1. To propose projects and programmes.

2. To review activities in nuclear science and technology in the African region.

3. To consider matters referred to it by the ECA or IAEA.

4. To make recommendations to the ECA Conference of Ministers.

5. To meet in regular sessions once every two years; and in extra-ordinary sessions as overriding needs dictate.

6. The experts nominated from the sub-regions should normally serve for a period of 4 years but may be re-nominated for subsequent terms.

129. The Chairman of the Technical Advisory Committee may be one of the experts from the sub-regions elected by the Committee to serve as Chairman for a period of two years between the regular meetings of the Technical Advisory Committee.

7. PROJECTS AND PROGRAMMES OF THE TECHNICAL ADVISORY COMMITTEE ON NUCLEAR SCIENCE AND TECHNOLOGY

130. Projects and programmes are not static but dynamic. Formally they should originate from the requests of member States, from the Technical Committee or from the Secretariats of organizations. Projects and programmes should be periodically reviewed, modifying some, dropping some and adding new ones. The benefits offered by applications of nuclear science and technology (NUST) as well as the areas of priority potential interest have already been fully presented in the review of the peaceful uses of nuclear energy in section 2, and selected areas of major interest to the region have been mentioned in the objectives and functions of the Committee above. It is expected that most of the projects and programmes will derive from them.

131. It is therefore not quite necessary to list projects and programmes with any pretension of finality at this stage. However, to initiate some activities the following projects are recommended:

1. For the purposes of sensitization, a version of section 2 of this report should be widely distributed;

(a) To member States requesting for country reports on current NUST activities as well as calling for comments and suggestions of projects and programmes.

(b) To centres, organizations such as universities, research institutes and key individuals likely to have interest in NUST, calling for comments suggestions of projects and programmes as well requesting information on their activities in NUST.

2. Coordination among activities already going on in the countries of the region in the applications of nuclear techniques to food and agriculture, water resources management, mining, health and medicine, industry and electricity generation, etc.

3. The applications of nuclear radiations may be going on in certain countries in the region without appropriate safety regulations. Efforts should be made to identify the countries, if any, and assist them in introducing appropriate safety regulations.

4. Facilities should be established at selected laboratories for radiation dosage standardization to serve sub-regional and regional needs. Radiation dosage standardization in the application of nuclear techniques to medicine and food preservation is extremely important. In medical applications, over-dose may cause death while under-dose may cause complications.

5. Assistance should be provided in the procurement and distribution of radioisotopes. It is not easy for countries without reactors to obtain supplies of radioisotopes.

6. Instrument maintenance and procurement of spare parts should be arranged at sub-regional and regional levels.

7. Manpower development through training courses, attachments and fellowships should start early.

8. Countries within the region that had earlier announced nuclear projects which are still unrealized should be contacted to explain their constraints and indicate in which way the Committee may assist them.

9. Inventory of human and natural resources and facilities in FUST within the region should be initiated immediately.

10. Documentation of FUST should be initiated immediately.